CAPACITORS

PACKAGING

Each capacitor style is made with different materials and contained in different packaging styles to give it unique functional characteristics. The capacitors in this section are divided into their technology categories as illustrated in Figure 1. A general comparison between all capacitor styles is shown in Table 1, and a more detailed comparison between the functional parameters of fixed capacitor styles is shown in Table 2. Note the numeric values given in Table 2 is for initial tolerance and stability after life testing for capacitors manufactured to Military performance specifications. They may not be indicative of similar commercial styles.

Frequency characteristics are especially important when selecting a capacitor style. All capacitors have frequency limitations due to the nature of the dielectric and other construction features. Figure 2 breaks down the frequency characteristics graphically. The frequency range of electrolytics is the most difficult to describe because effective capacitance involves a complex relationship between voltage rating, case size, nominal capacitance value, and operating frequency. Alternating currents and operation under pulse and energy storage conditions adds further complexities.

In addition to voltage rating, heat dissipation must also be taken into account. Heat is generated as a result of Equivalent Series Resistance (ESR), dielectric losses, and to a lesser extent, by losses in the attachment of lead wires to the capacitor elements.

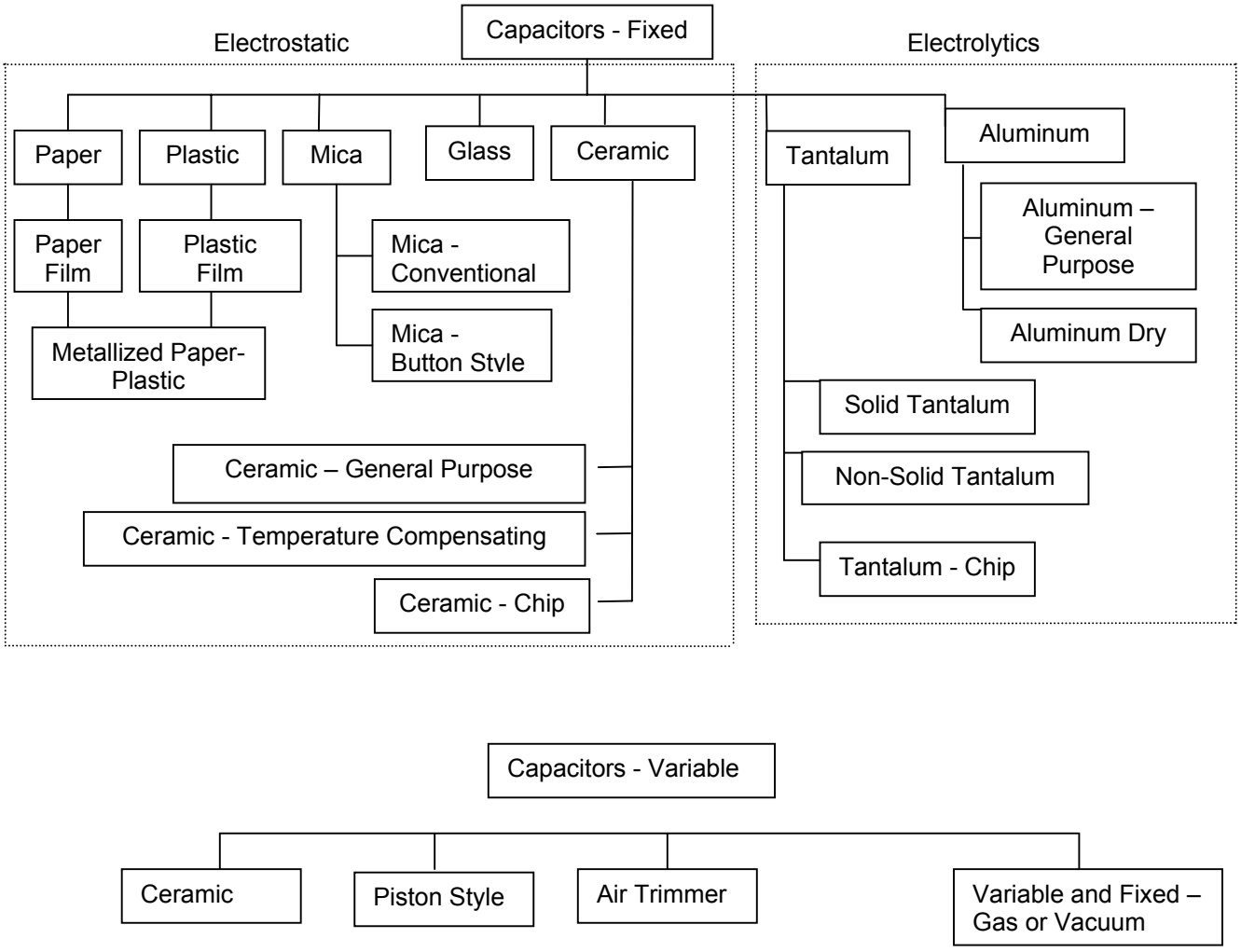

Figure 1. Capacitor Technology Tree

Table 1. Summary of Application Characteristics by Capacitor Style

Capacitor Style	Application Information
Electrostatics	
Fixed, Paper Film	Low cost, low reliability style available in medium capacitance values (0.001 μf – 30 μf). Film/Foil capacitor style designed for circuits requiring high insulation resistance, low dielectric absorption, and where ac component of voltage is small. Not intended for high humidity applications.
Fixed, Plastic Film	Broad class of capacitor style with similar failure characteristics and modes but manufactured with different plastic Styles. Generally intended for high voltage applications where the ac component of voltage is small in comparison to the dc component. Same as above, except higher in cost, higher in capacitance per volume, and less sensitive to environmental conditions.
Fixed, Metallized Paper and Plastic	Same as above, except the metallization process increases voltmetric efficiency and provides self healing process at the expense of decrease low impedance, low voltage performance.
Fixed, Mica, Conventional	Low capacitance value, high frequency capacitor style intended for use in circuits requiring precise filtering, bypassing, and coupling.
Fixed, Mica-Button	Small size, low capacitance value, high frequency style. Typical uses are in tuned circuits and in coupling and bypassing high frequency applications.
Fixed, Glass	Rugged, small size, low capacitance value style with good high frequency characteristics and able to withstand high temperatures. Intended for applications where high insulation resistance, low dielectric absorption, and fixed temperature coefficients are important.
Fixed, Ceramic, General Purpose	Small physical size capacitor with comparatively large electrical capacitance and high insulation resistance. Intended for surface mount applications.
Fixed, Ceramic, Temperature Compensating	Intended to compensate for temperature induced variance from other circuit elements. Used for highly accurate circuits where change in capacitance value cannot be tolerated.
Fixed, Ceramic, Chip	Small size capacitor intended for surface mount applications. Use where high accuracy applications where variation in capacitance values with respect to temperature, voltage, and life can be tolerated.
Electrolytics	
Fixed, Tantalum, Chip	Small size chip capacitor intended for relatively low voltage surface mount applications. Intended for similar applications as ceramic chip capacitors, but where higher voltmetric efficiency is needed.
Fixed, Electrolytic, Tantalum, Solid	Low frequency, high capacitance style. Primary application is power supply filtering. Higher capacitive density, but more expensive and higher leakage current than aluminum styles. Category covers both molded and dipped styles.
Fixed, Electrolytic, Tantalum, Non-Solid	High capacitance value capacitor, used primarily in low frequency filtering applications. Category covers plain foil, etched foil, and sintered slug capacitor styles, each with unique functional characteristics.
Fixed, Electrolytic, Aluminum (General Purpose)	Most common electrolytic. High capacitance density, high voltmetric efficiency, and low cost. Used primarily for low frequency filtering. Not recommended for airborne applications.
Fixed, Electrolytic, Aluminum (Dry)	High capacitance density, high volumetric efficiency, and low cost style used primarily for low frequency filtering. Most common electrolytic. Not recommended for airborne applications.
Variable	
Variable, Ceramic	Non-linearly adjustable, small sized trimmer capacitors designed for applications where fine tuning is periodically required during the life of equipment.
Variable, Piston	Linearly adjustable, small sized trimmer capacitors designed for applications where fine tuning is periodically required during the life of equipment.
Variable, Air Trimmer	Large capacitor intended for line rectification applications.
Fixed-Variable, Gas/Vacuum	Non-Linear variable capacitor intended for high power applications.

Table 2. Technical Performance Characteristic Comparison of Various Capacitor Styles

Characteristic	Paper-Plastic	Mica	Glass	Ceramic	Tantalum	Aluminum
Capacitance Range	1pF to 50µF	1pF to 90µF	0.5pF to 20µF	0.1pF to 1,000µF	50pF to 1,200µF	500pF to 200,000µF
DC Rated Voltage (V)	30 to 2000	50 to 2,500	100 to 1,250	50 to 1,500	3 to 500	5 to 500
Initial Tolerance	±0.5 to 20%	±1 to 10%	0.25pF to 5%	0.5pF or 1% to 20%	-5 to +75%	-10 to +75%
Stabilit[1]	<2 to 10%	<1 to 5%	0.5% or 0.5pF	3 to 20%	<15%	<15%
Relative Size for Equivalent CV Rating	Small to Large	Large	Large	Fixed-Small Variable-Large	Very Small	Medium to High
Relative Cost for Equivalent CV Rating	Medium to High	Medium	Medium	Low	Very Small	Medium

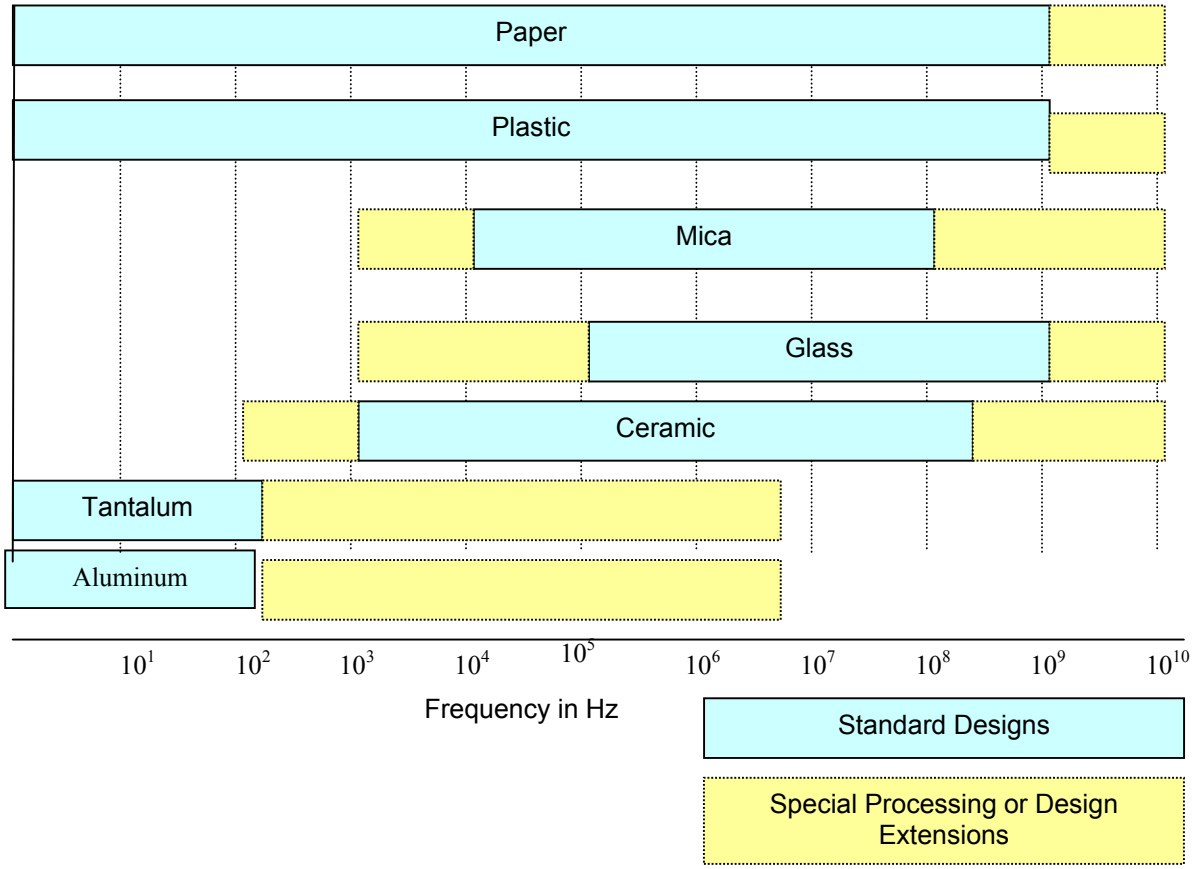

Figure 2. Operating Frequency Limits of Capacitors

[1]Stability is measured after a 2,000-Hour life test for the capacitors manufactured to the Military performance specifications. Value may not be indicative of commercial styles.